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Extension of the operating parameters of the two stage light gas gun to velocities below 2 km/sec

Robert S Thoe

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Robert S Thoe
Lawrence Livermore National Laboratory
Livermore, Ca 94550

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Extension of the operating parameters of the two stage light gas gun to velocities below 2 km/sec.

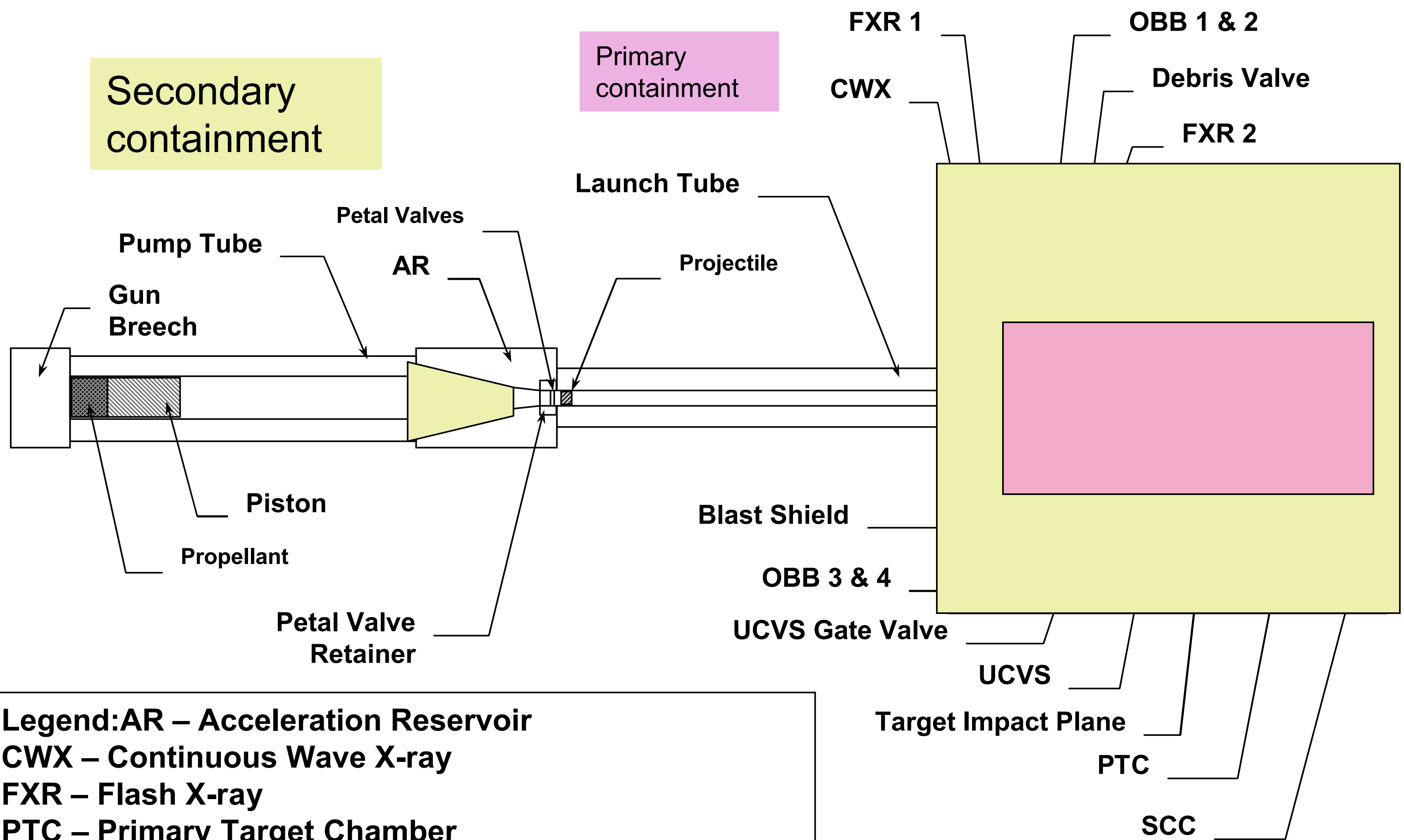
- JASPER facility
  - Capabilities
  - Requirements
  - Operations
- Livermore facility
- Predictive capabilities

The JASPER Compound

- The Joint Actinide Shock Performance Experimental Research Facility (JASPER) is a two stage light gas gun located in Area 27 at the Nevada Test Site (NTS)
  - Impact actinide targets (primarily Pu) with high velocity projectiles (2 km/s to 8 km/s) to improve equation of state models

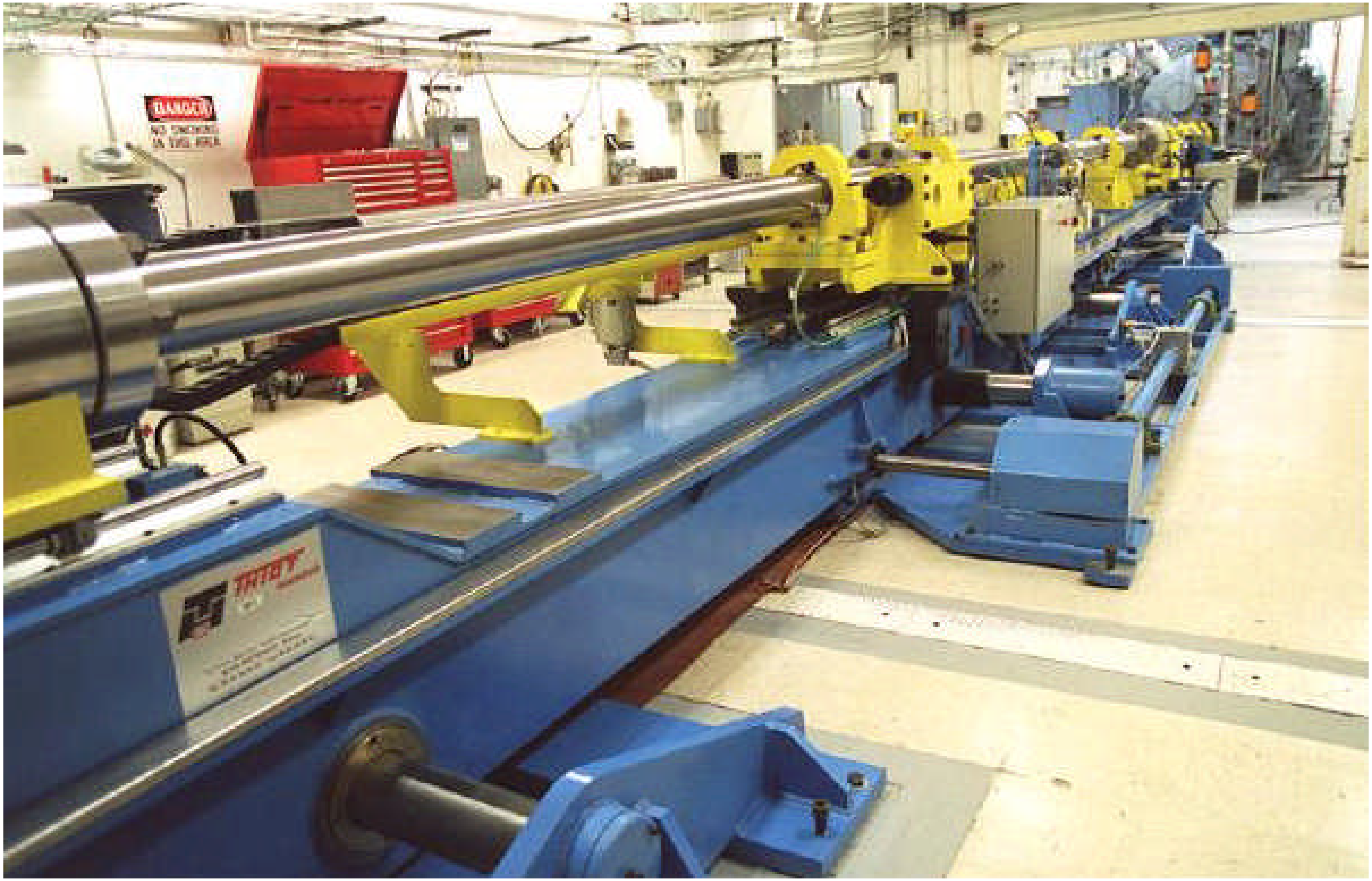
Aerial view of the JASPER Facility site.

Schematic of the JASPER Gas Gun, SCC, & PTC

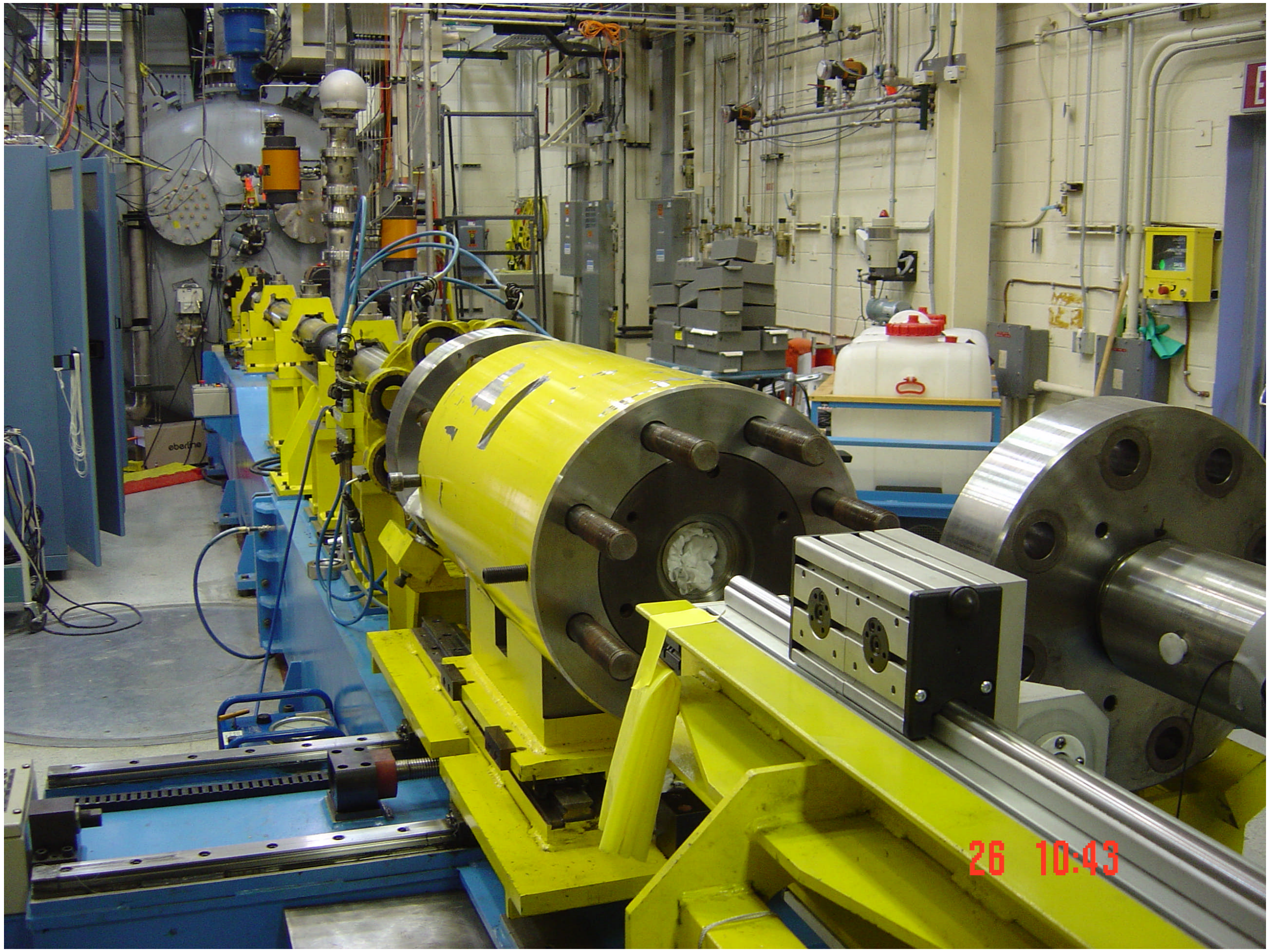


Legend:AR – Acceleration Reservoir
CWX – Continuous Wave X-ray
FXR – Flash X-ray
PTC – Primary Target Chamber
OBB – Optical Beam Break
SCC – Secondary Containment Chamber
UCVS – Ultra-fast Closure Valve System

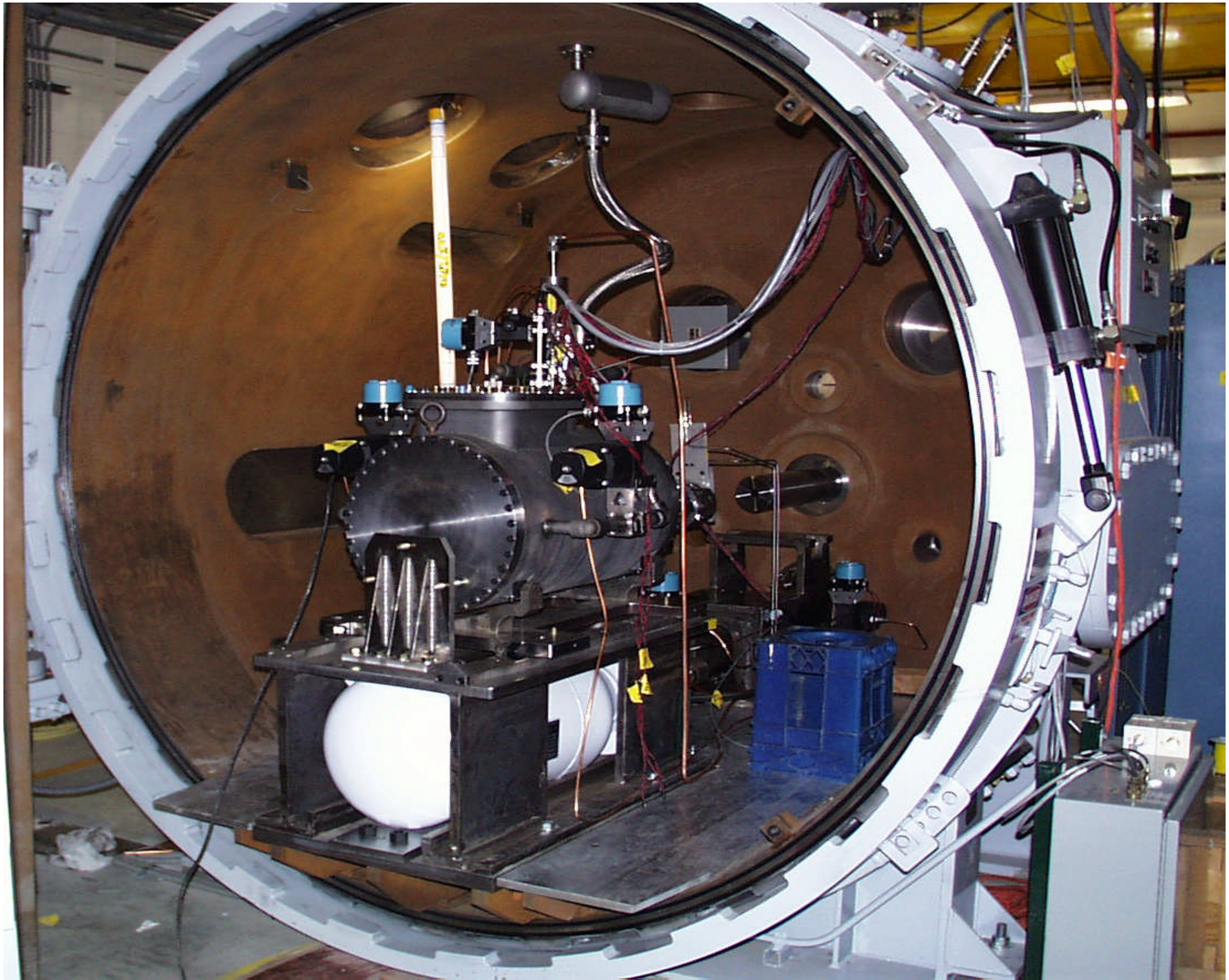
View of JASPER target chamber as seen from the breech



JASPER AR and target chamber

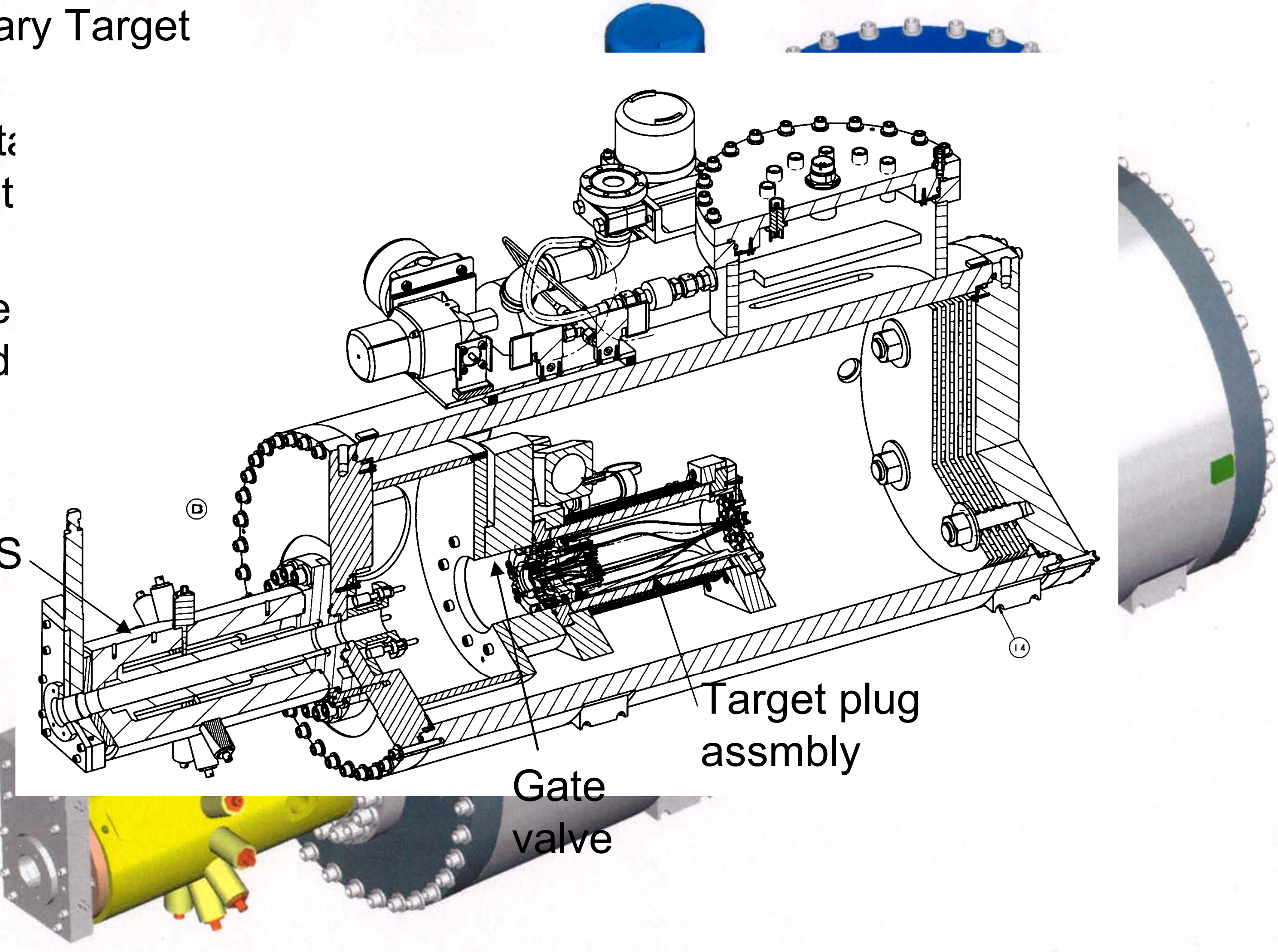


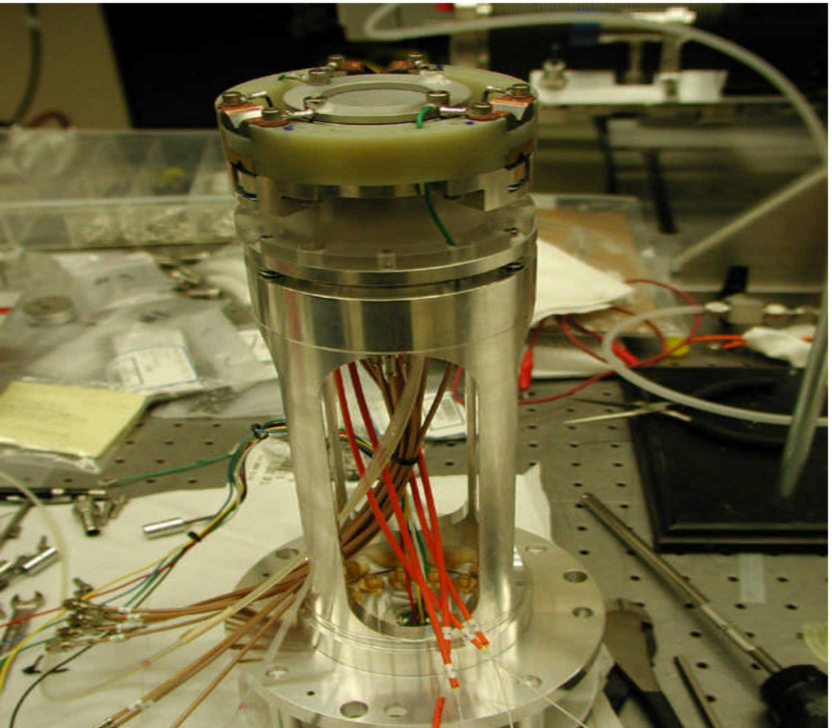
SCC with PTC being installed



The Primary Target Chamber contains the Target impact load and debris

- Pu targets will be installed and contained in a Primary Target Chamber (PTC)
- The PTC will be insta
in a Secondary Cont
Chamber (SCC)
- Expended PTCs are
placed in a standard
waste box for
eventual disposal

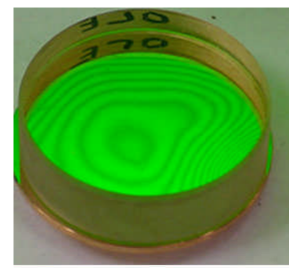




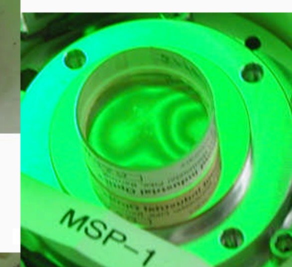
Containment adds considerable complexity and expense to experiments

- Target plug assembly resides behind a gate valve and automatically docks between the gate valve and UCVS prior to shot
- Alignment done prior to shipping with a surrogate
- Target metrology shows tolerance good to 2 microns (flat and parallel)

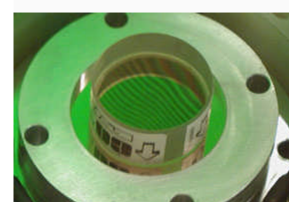
- These tolerances as well as corresponding alignment tolarance must be held as the target is remotely deployed
- Once Gate vale is opened target **WILL** be shot.



Flatness tested prior to loading



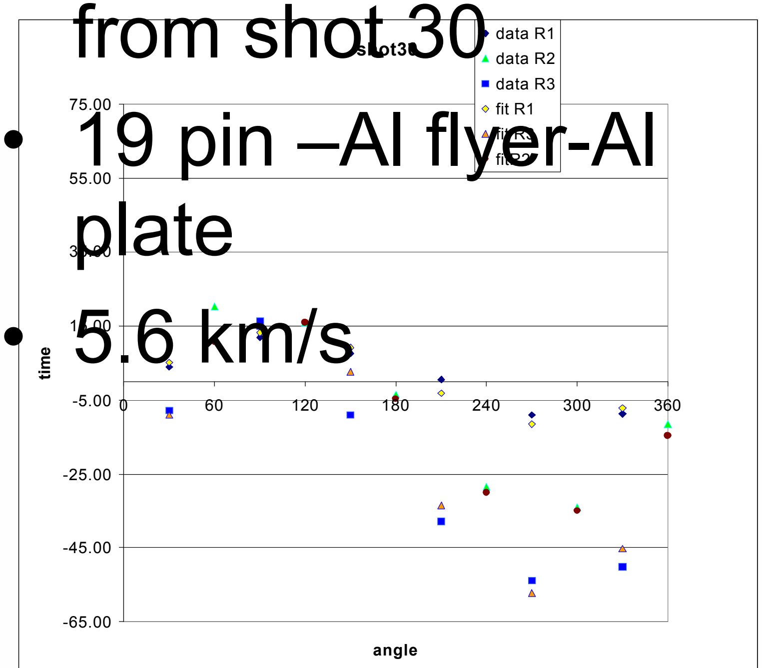
Flatness tested after loading

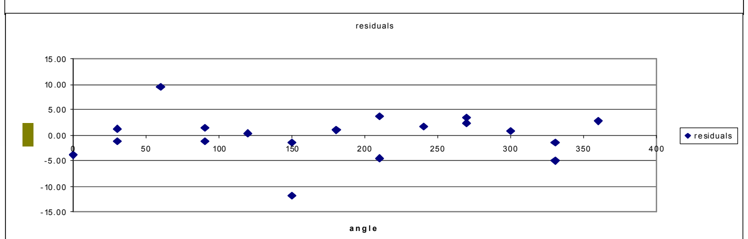


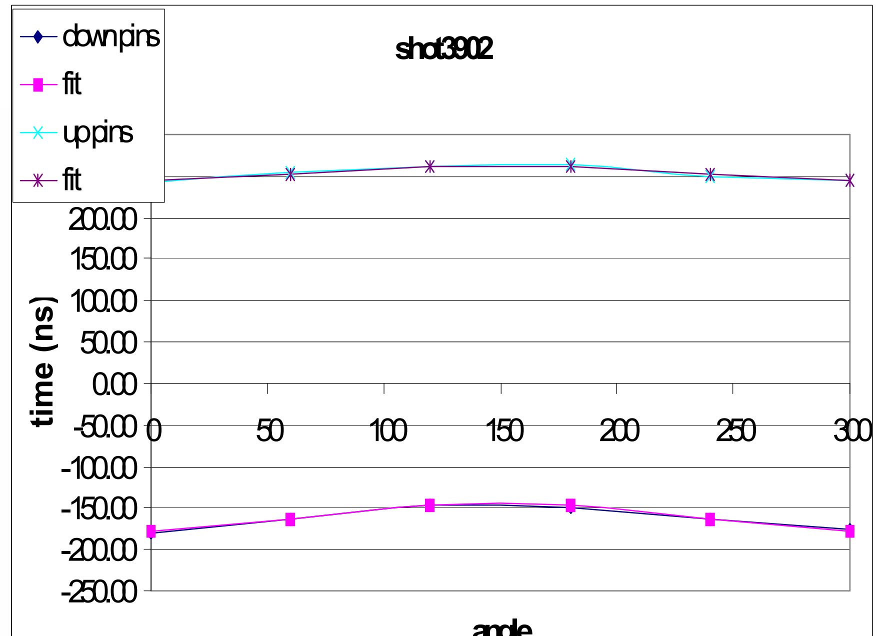
Flatness tested on finished target

Incorrect gun operating parameters can cause flyer distortion

- Surface measured from shot 30
- 19 pin –Al flyer-Al plate
- 5.6 km/s







In order to mitigate these effects and be able to shoot at velocities < 2 km/s a study was taken using a one D 2 stage gas gun ballistics code

- Code was originally developed by Charters & Sangster[1]
- It was modified it and several new features installed
  - Several propellant types built in
  - GUI allows easy change of input deck, including gun dimensions and zoning
  - New EOS for a variety of drive gases (ideal gas and Van der Waals)
  - Fixed up petal valve opening time
  - Automatically provide plots + text files
  - Automatically writes new input file
    - Makes it easy to generate new default deck
    - Easy to check what the code actually read
  - Structure much simpler –used for only 2 stage GG
  - Designed to be useful and be run by gunners

1 Charters A. C., and Sangster, D. K., Computer program for the Interior Ballistic Analysid of Light Gas Guns. Unpublished Manual to CFD code , 1973

Shot records at our Laboratory were studied dating back almost 30 years

1. Many low velocity shots used to develop long rod penetrators
    - These projectiles were often heavy ~ 100 gm compared to our ~ 17 gm sabots
    - Many slow shots with light sabots used N_2 for drive gas
    - No diagnostics on flyer planarity
    - From JASPER experience we knew we wanted lower drive gas pressures ~ 10 bar
    - Low fill gas pressures generally gave high velocities.
2. Preliminary experiments using low propellant charges (WC 890) gave the following results:
    - Low propellant charges tended to burn erratically
        - Needed charges as low as 350 gm
        - Burn rate a sensitive function of pressure
        - Breech designed for charges up to 3500 gm
        - Actually bounced a piston, luckily no containment breech

Used technology developed at SNL[2]

This method required several watts of light in open beams, When we tried it we had very little light returned

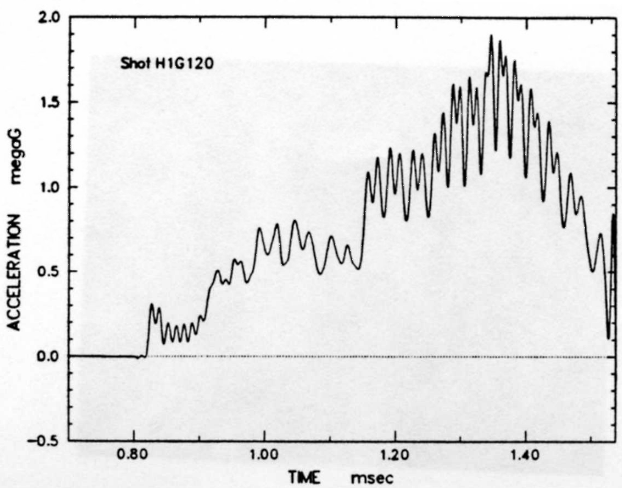


Fig. 6. VISAR acceleration record for shot #H-120.

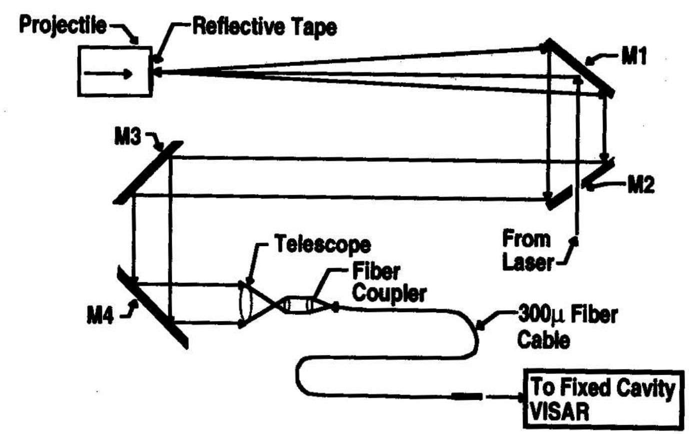
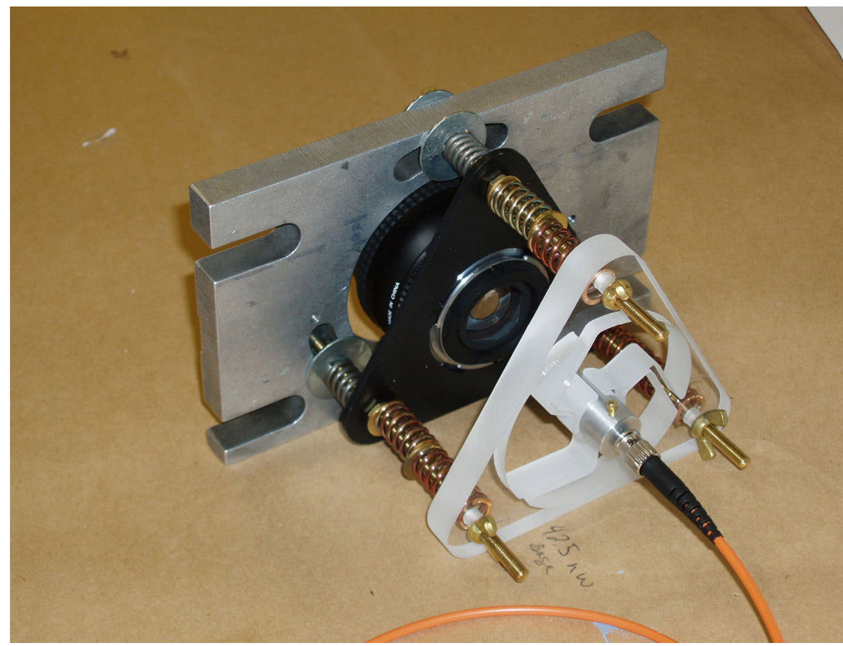


Fig. 4. Experimental VISAR setup configuration.

2 Konrad, Cox, Asay, and Hall "Radar and VISAR Measurements of Interior Ballistics in AEDC's Upgraded Ballistic Range Facility", AIAA 94-0234, 33rd Aerospace Sciences Meeting and Exhibit, Jan 9-12/ Reno Nv.

Our VISAR experiment used a single pair of fibers with a standard camera lens

1. Required only a few mW of light to get strong return.
2. Intensity would sometimes vary strongly but not enough to hurt the data



Low velocity parameters

- N2 was used initially for drive gas, wc 890 for propellant
  - Simulations showed that N_2 imparted a lot of stress to the projectile
- Low velocity with little stress could be achieved provided the petal valve could be made to open at relatively low pressures
- 350 gm WC 890 changed to ~1000 gm M6
- Petal valve changed from a 35 /62 to 30/62 (2500 psi from 4500 psi)
  - Going to a thinner PV resulted in PV not opening all the way
- Change piston from 8 lb to 15 lb piston
  - This allowed us to use more propellant
  - This increased the pistons energy, without increasing its velocity
- Flyer velocity could be modified by changing PV opening stress, changing PV opening time (knobs)

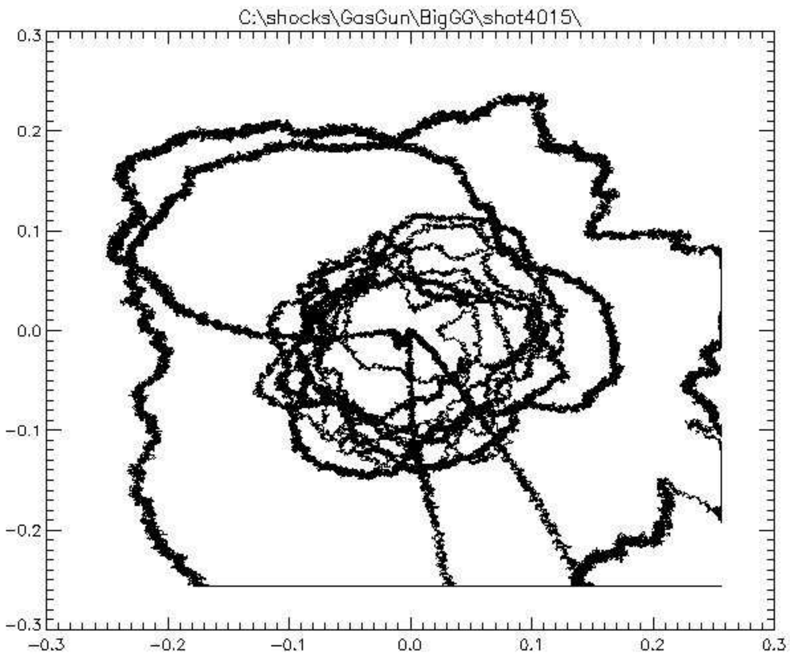
- **Goal: provide slow flyer velocities with maximum piston penetration into the AR**

Shot 4015

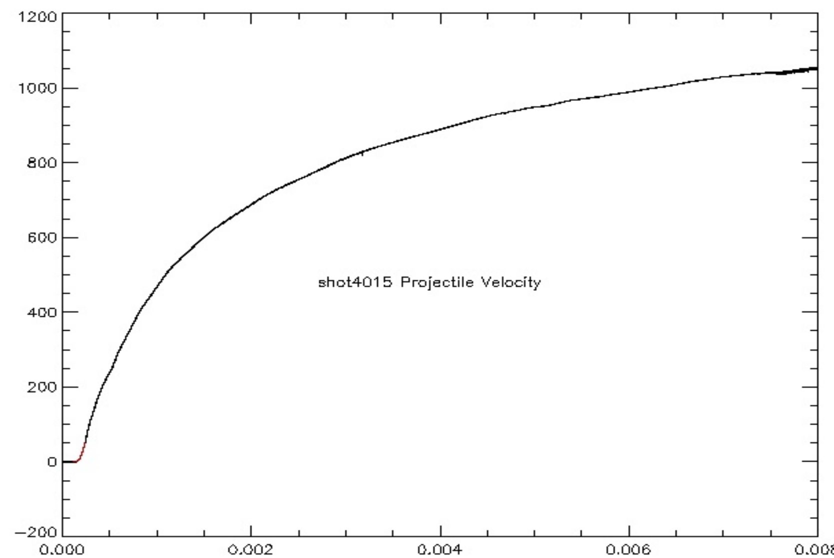
8 bar N_2,   15 lb piston, PV opening time =2 ms, burst pressure 3.5ksi

650 gm of M6,

Vflyer = 1.18 km/s



Lissajous

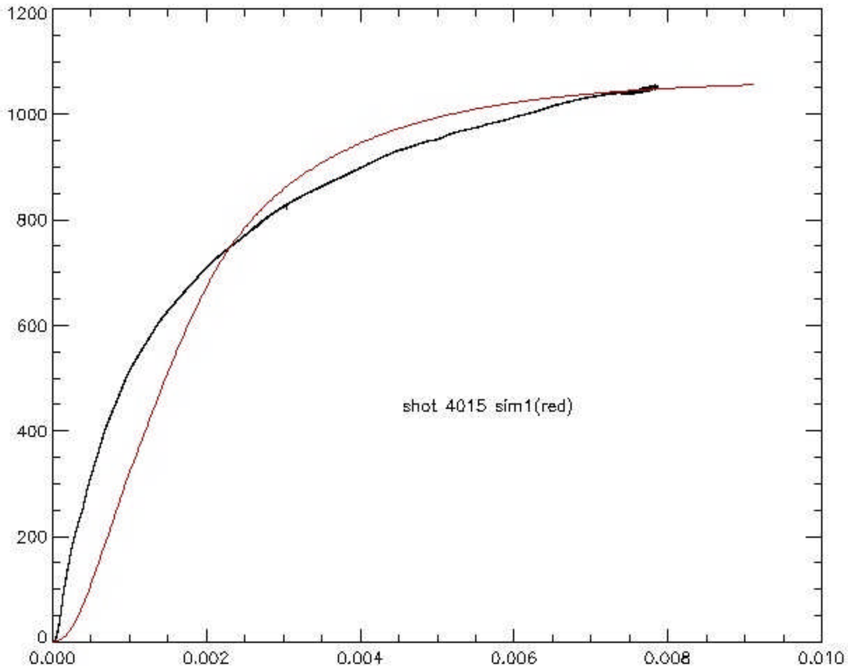


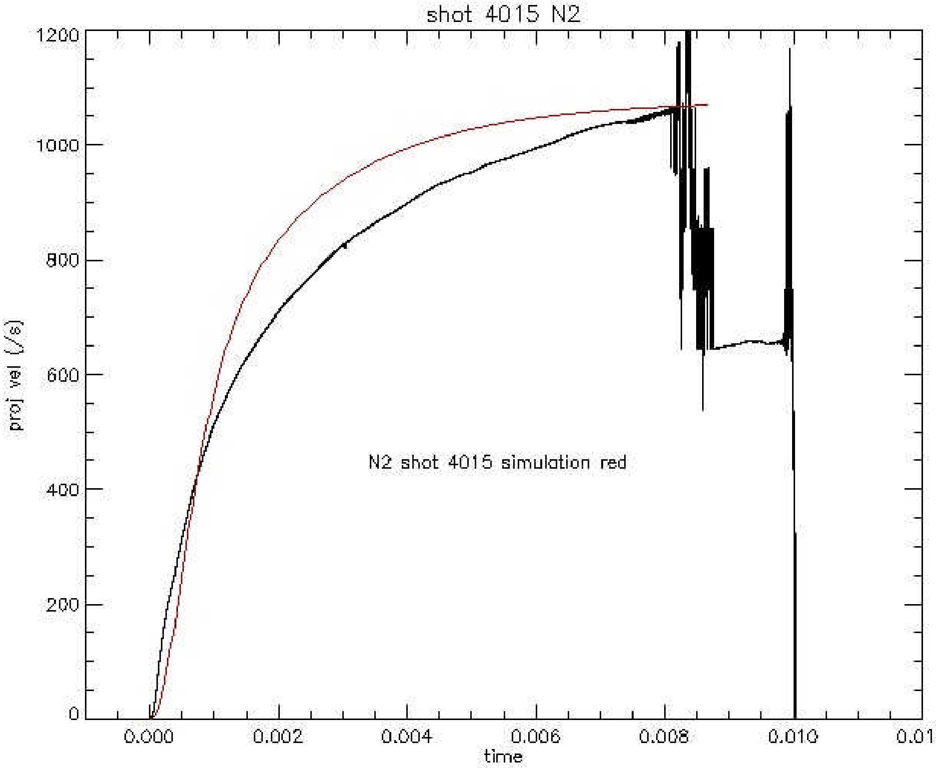
Velocity profile of projectile

Changed the EOS of drive gas from ideal to Van der Waals

- Ideal gas

Van der Waals

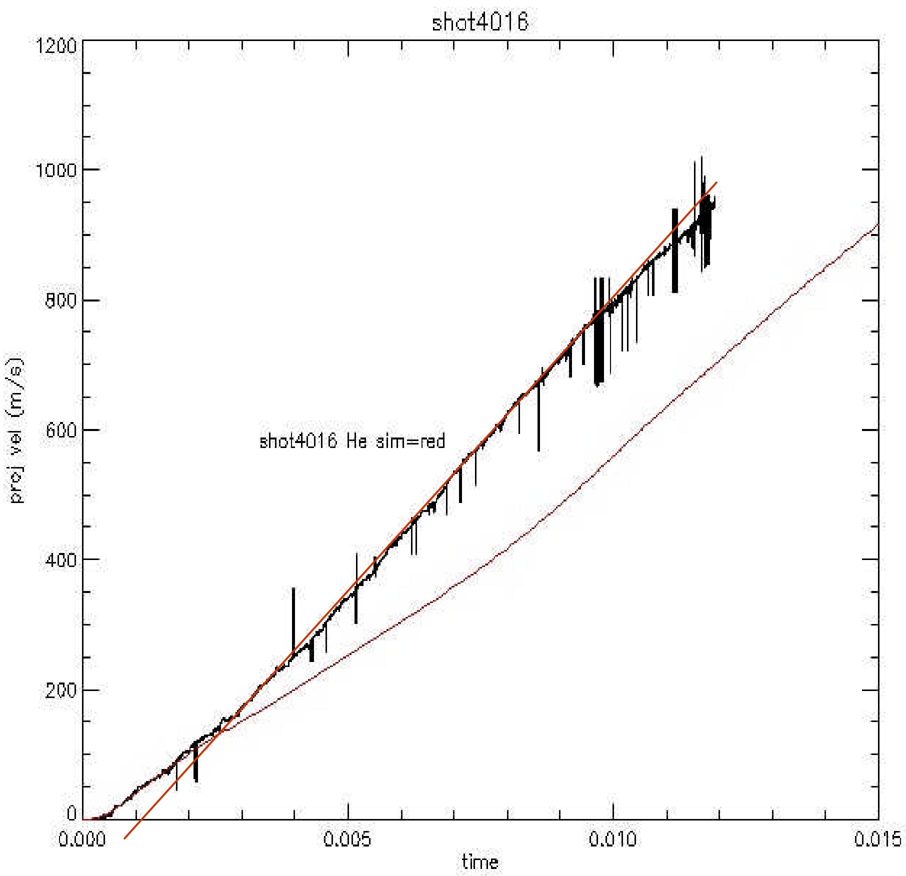




Adjusted PV opening time to get correct velocity, Van der Waals gives higher initial stress

Next use He for a drive gas

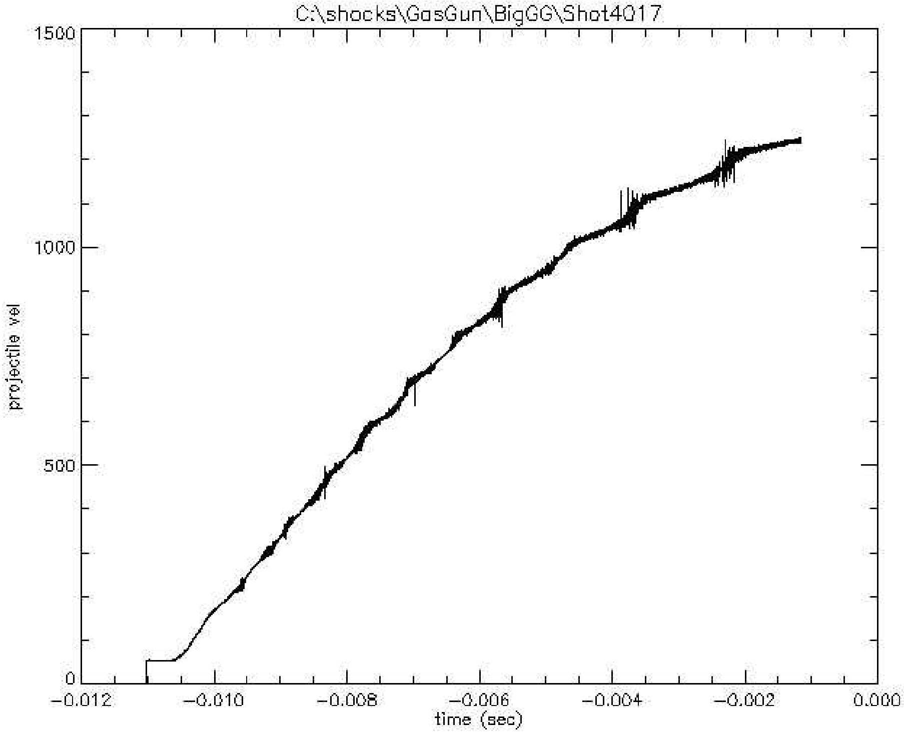
- Shot 4016
  - He drive gas 8 bar
  - PV press 1000 psi
  - 750 gm M6
  - 15 lb piston
  - Projectile 38.5 gm
  - Vflyer 1.11 km/s
  - PV 10/62



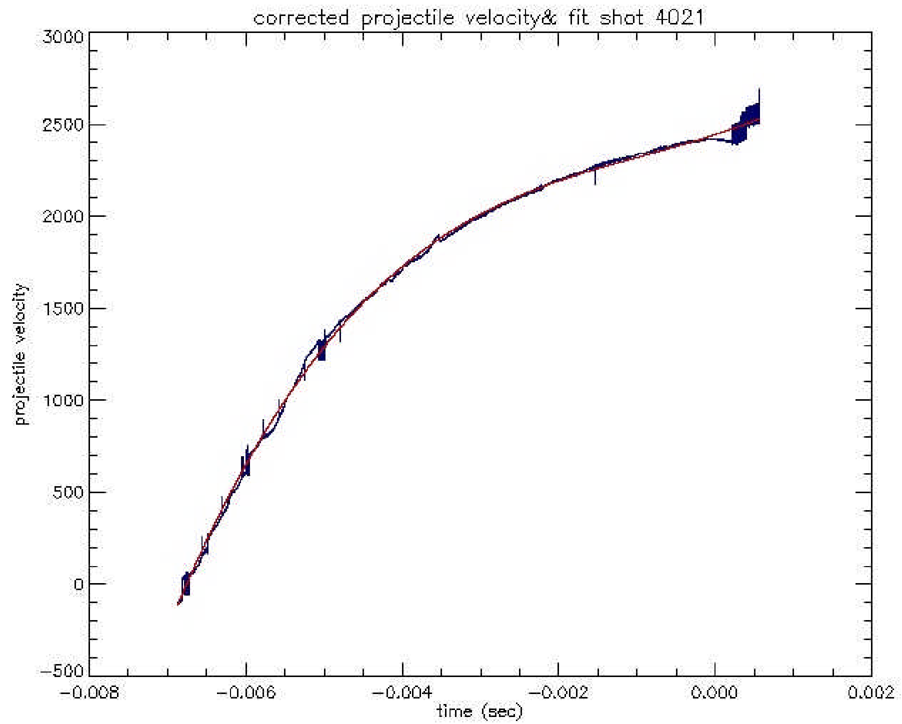
Projectile trajectory

Other shots done for flyer velocities between 1.8 and 2.2 km/s

Examples measured projectile trajectories for shots 4017 and 4021

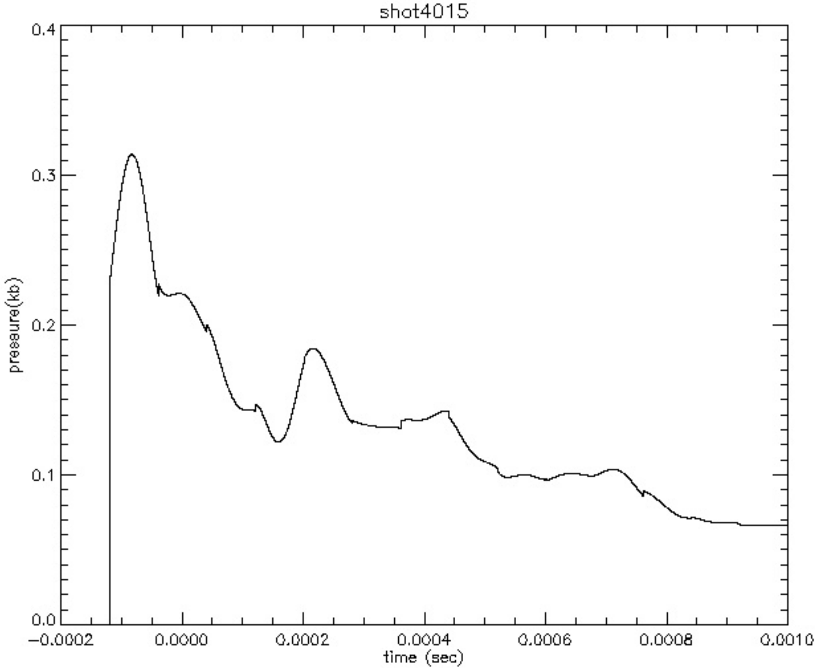


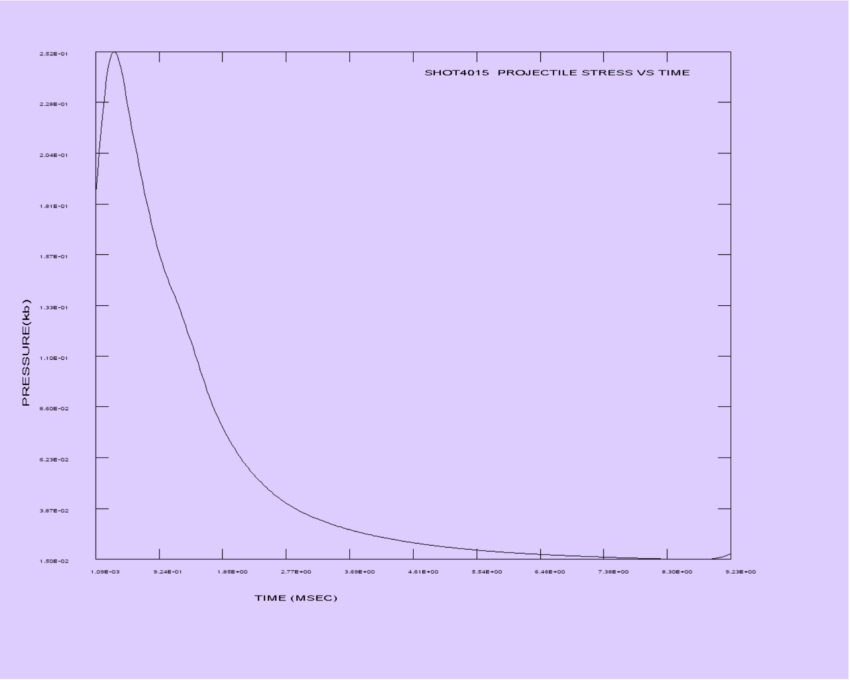
Shot 4017 PV 28/62



shot 4021 PV 30/62

Using He instead of N2 reduced stress considerably





Numerous shots all gave results to within a few percent

shot	F_vel	projectile	PV	PVP	pwdr	pwdr wt	gas	gas_press	piston	proj stress
4015	1.116	17.2	35/62	3500	M6	650	N2	125	15	0.26
4016	1.11	38.5	10//62	400	M6					0.04
4017	1.232	45.29	28/62	650	M6					
4018	bounced	45.3	35/62	6500	M6	550	He	145	15	0
4019	1.837	45.35	30/62	1150	M6	900	He	145	15	0.1
4020	2.55	45.6	30/62	2000	M6	1400	He	145	15	0.25
4021	1.88	45.6	30/62	1250	M6	950	He	145	15	0.123
4022	2.15	45.413	30/62	1535	M6	1100	He	145	15	0.15
4023	1.98	45.5	30/62	1350	M6	1000	He	145	15	0.135

Shots 4016,4017 PV didn't open all the way

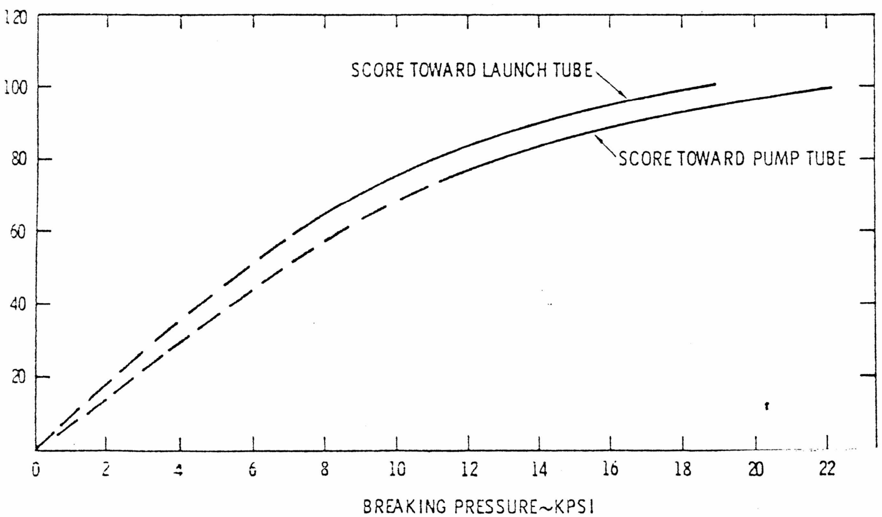


Figure 11 Relationship of Breaking Pressure to Web Thickness for Two 0.060" Thick Petal Valves — 1-1/8 Inch Petal Valve Retainer

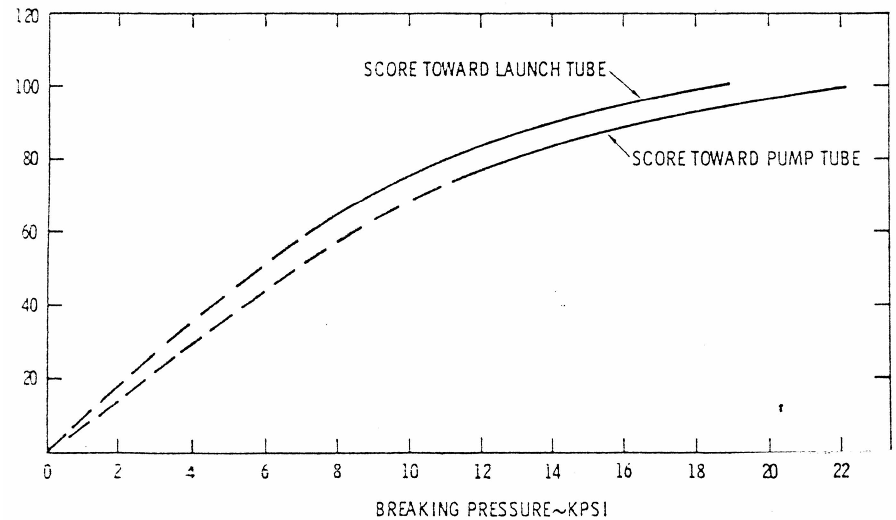


Figure 11 Relationship of Breaking Pressure to Web Thickness for Two 0.060" Thick Petal Valves — 1-1/8 Inch Petal Valve Retainer

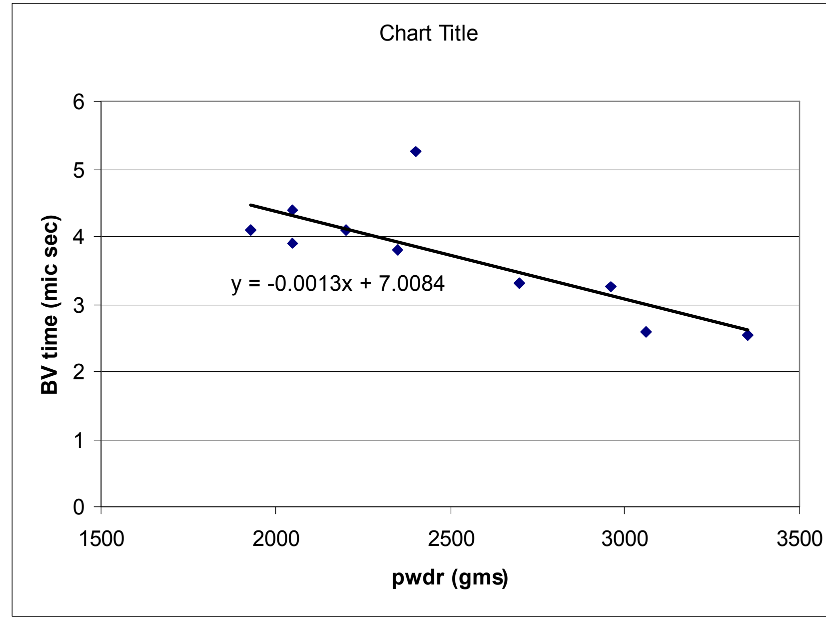
There are four knobs

- Piston release pressure
  - V_{flyer} very insensitive to this
- Friction
  - V_{flyer} very insensitive to this
- PV burst pressure
  - V_{flyer} very insensitive to this
- PV opening time
  - Almost linear function of Powder load

There are four knobs

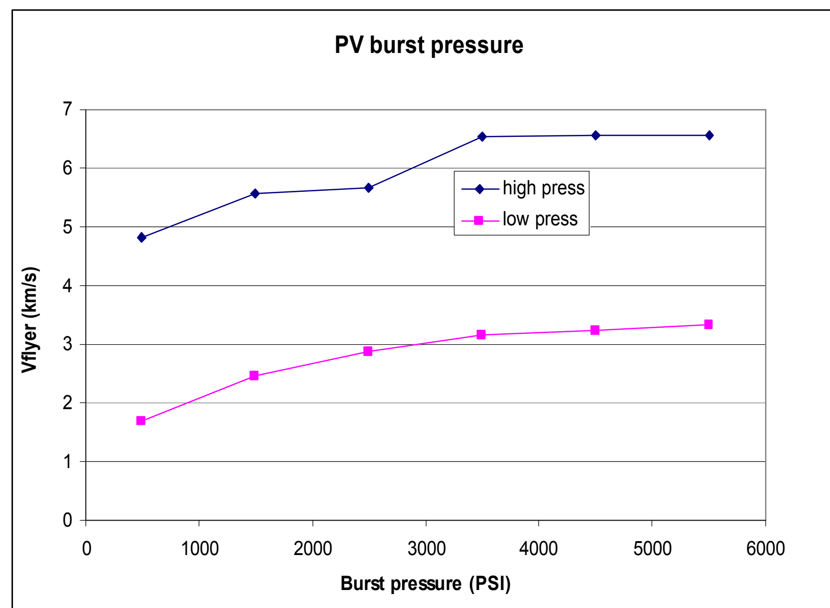
PV opening time can be estimated pretty well as a linear function of propellant load

- This could be incorporated into the code
- New fitting coefficients for each propellant
- New coefficients for piston weight

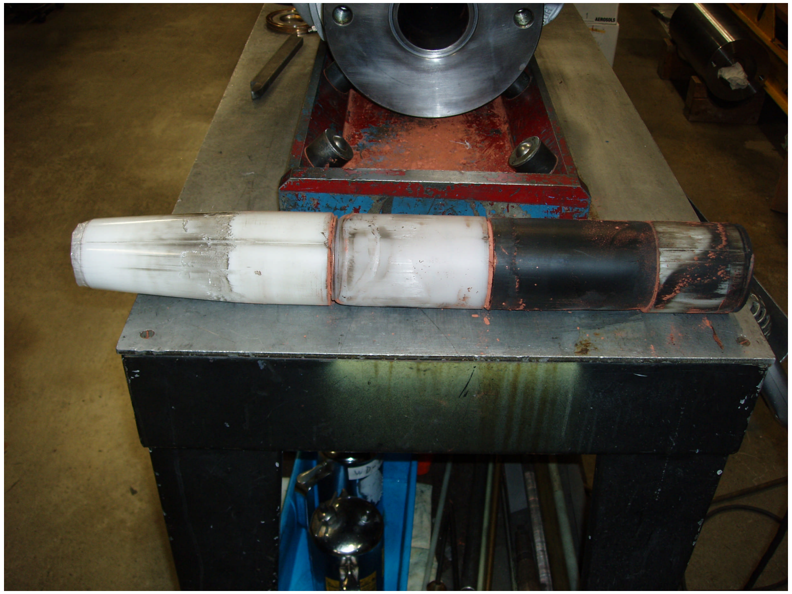


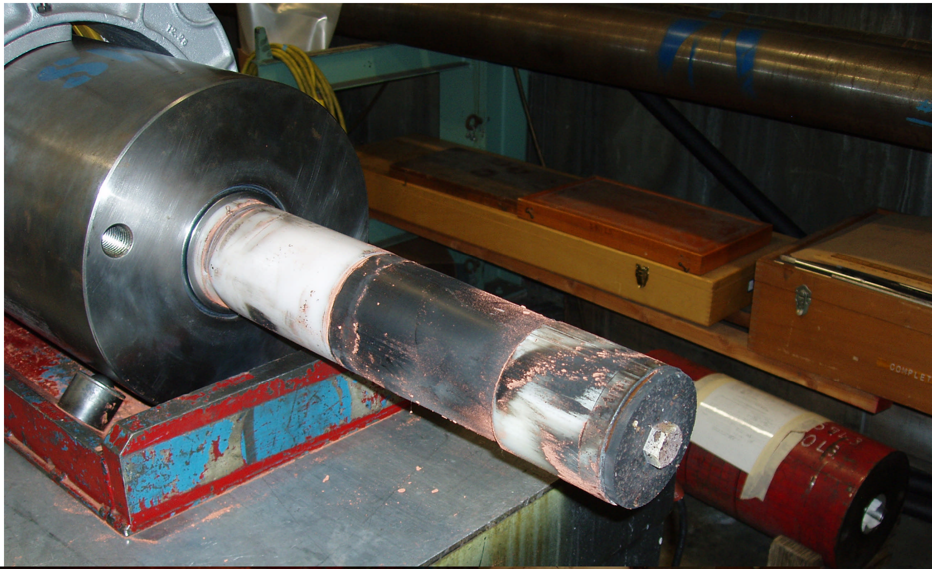
PV burst pressure mostly has effect for high pressure PV

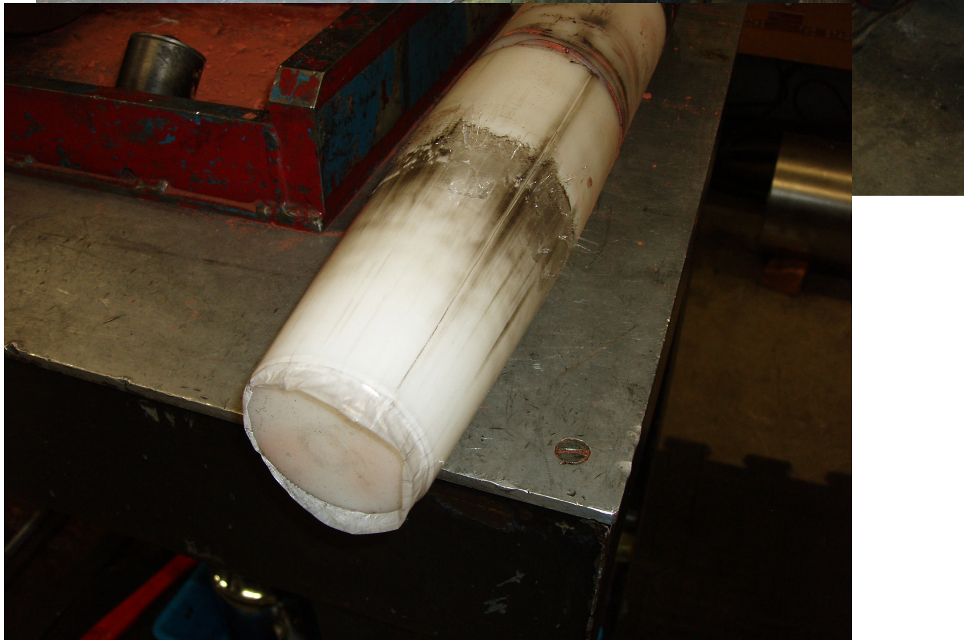
- Biggest effect for low velocity shots
- Almost no effect for large powder loads
- Simulation is for 28 gm projectile, 10 bar pump tube pressure and an 8 lb piston



Typical result of Livermore shot

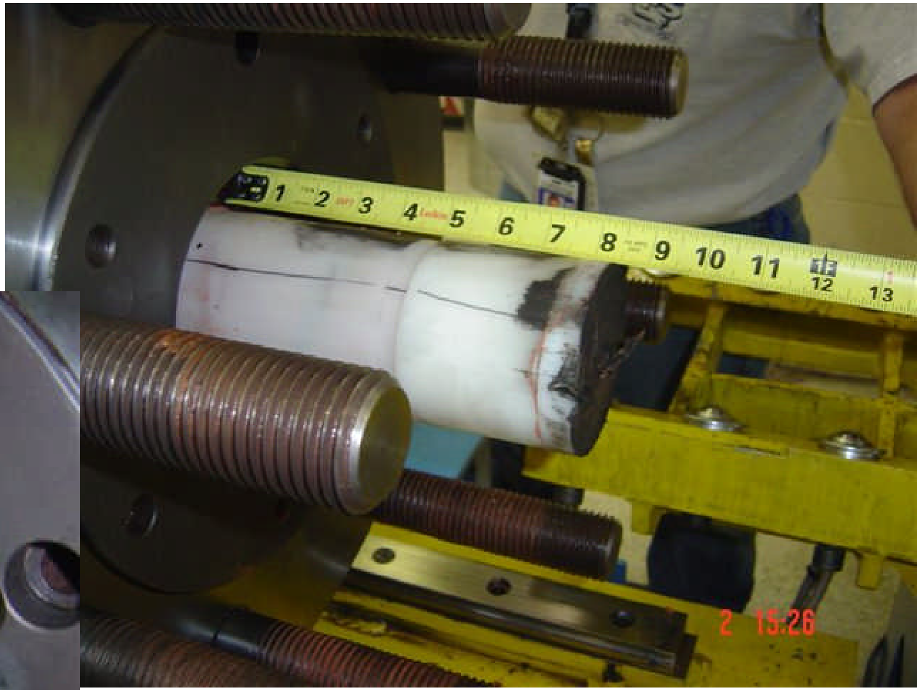


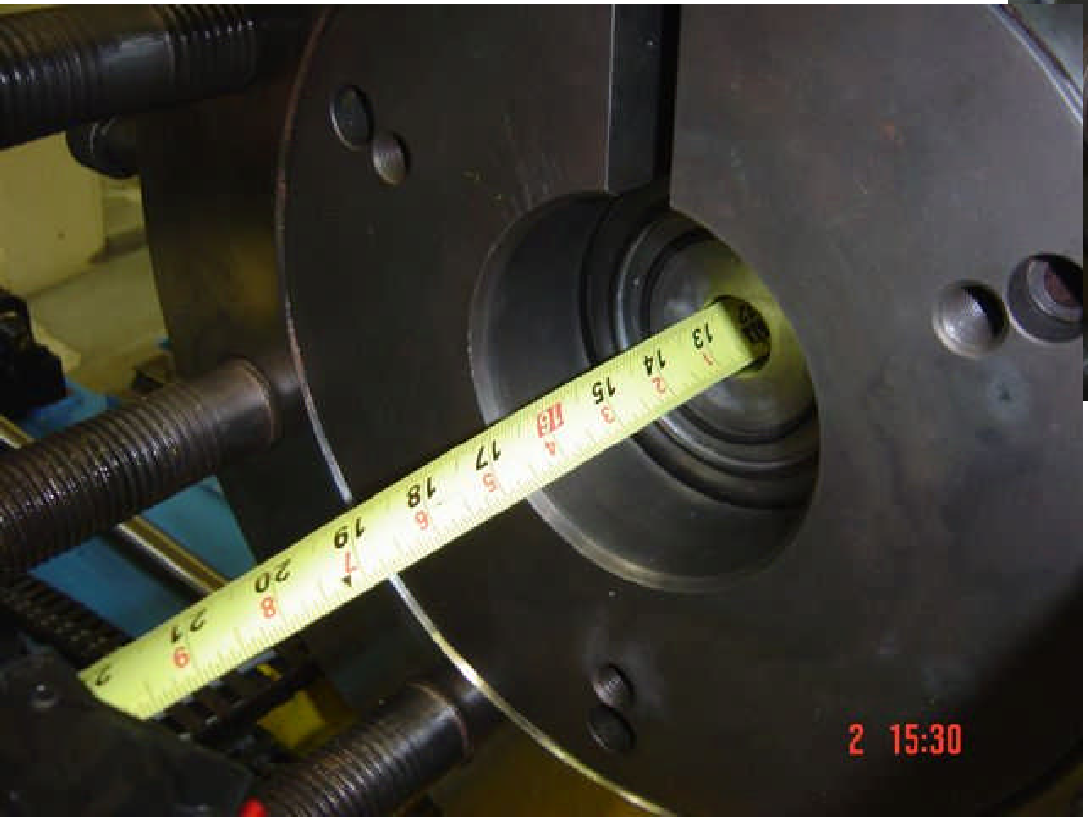




Results of shot JAS71

Piston wedged deeply in AR





24” piston in taperd section of AR almost 13 “

Jasper shot 71 Piston

Conclusions

- To obtain reliable containment for flyer speed below 2.5 km/s
  - Use 15 lb piston
  - Use He pump gas 10 bar
  - Use heavier projectile nominally 45 gm
  - Use a somewhat thinner PV 30/62

Conclusions cont'd

- Using PV thinner than 30/62 results in to low a pressure in AR and PV does not open all the way
  - This leads to extremely slow velocities
  - Unreliable code predictions
- Stay away from N_2 drive gas
- Thinner PV's lead to less predictive capability